

A view on mid-tropospheric CH₄ in the tropics: 6 years from MetOp-A/IASI

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Introduction

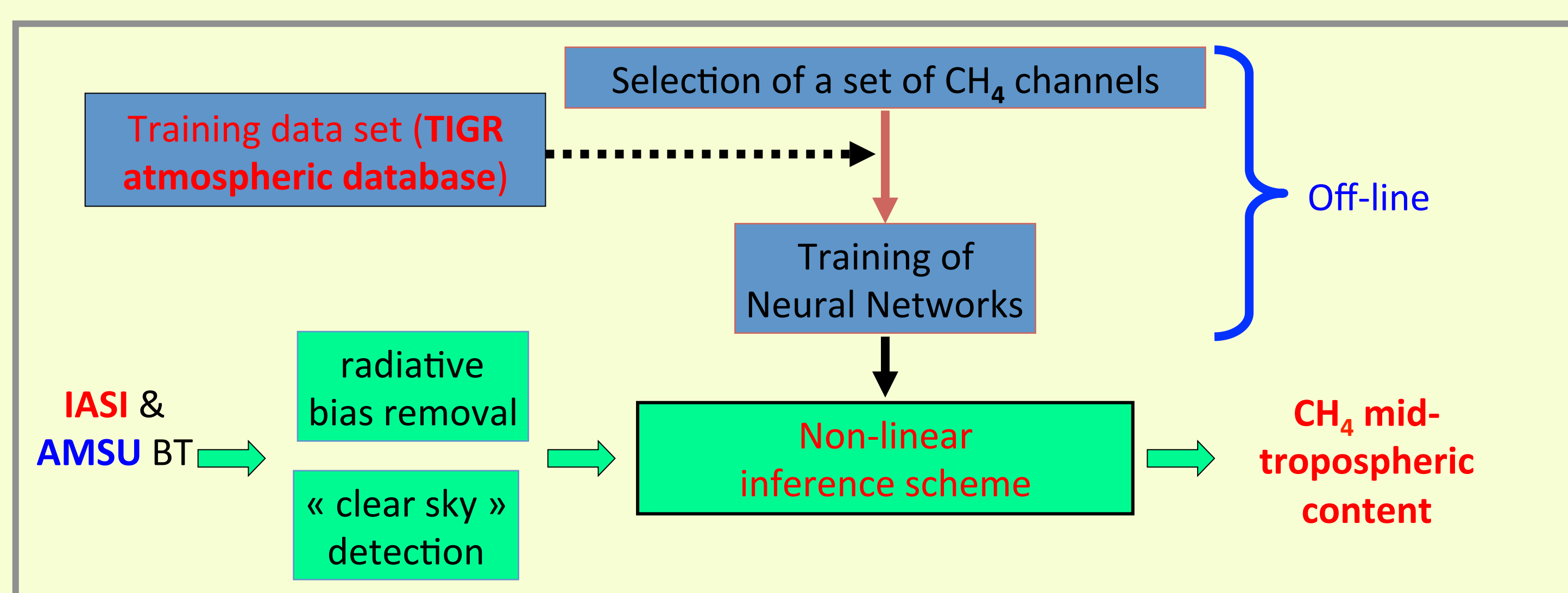
Methane (CH₄) is the third most important greenhouse gas in the atmosphere, after water vapor and CO₂, and plays a significant role in tropospheric chemistry through its removal of OH. There is thus a considerable interest in monitoring its evolution to better characterize its atmospheric budget and infer how it might evolve in the future.

The rate of increase in CH₄ has been steadily decreasing since the late 1980s, reaching a near-zero increase from 1999 to 2006. From the end of 2006 or beginning of 2007, a renewed growth of atmospheric CH₄ has been observed by surface networks (Rigby et al., 2009; Dlugokencky et al., 2009), potentially stemming from a combination of a slight change in OH, and increased emissions in northern high and low latitude regions.

Here, we present 6.5 years of mid-tropospheric methane derived from the Infrared Atmospheric Sounding Interferometer (IASI) over the tropics, spanning July 2007-Dec. 2013, from which we infer characteristics of tropospheric methane and its most recent evolution.

The retrieval method

Use is made of a **non linear inference scheme** based on neural networks (Crevoisier et al., 2009), initially designed for the retrieval of CO₂ (Chédin et al., 2003).



• Simultaneous use of IR (IASI) channels sensitive to T and CH₄ and of MW (AMSU also flying onboard MetOp-A) channels only sensitive to T allows to **decorrelate T/CH₄**.

• The retrieval is limited to the **tropical zone** because of the greater stability of the tropospheric temperature vertical which yields a better precision.

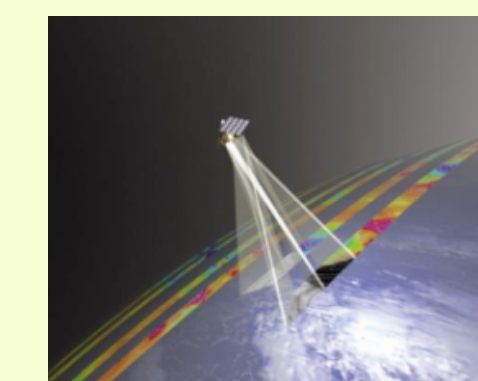
The IASI instrument



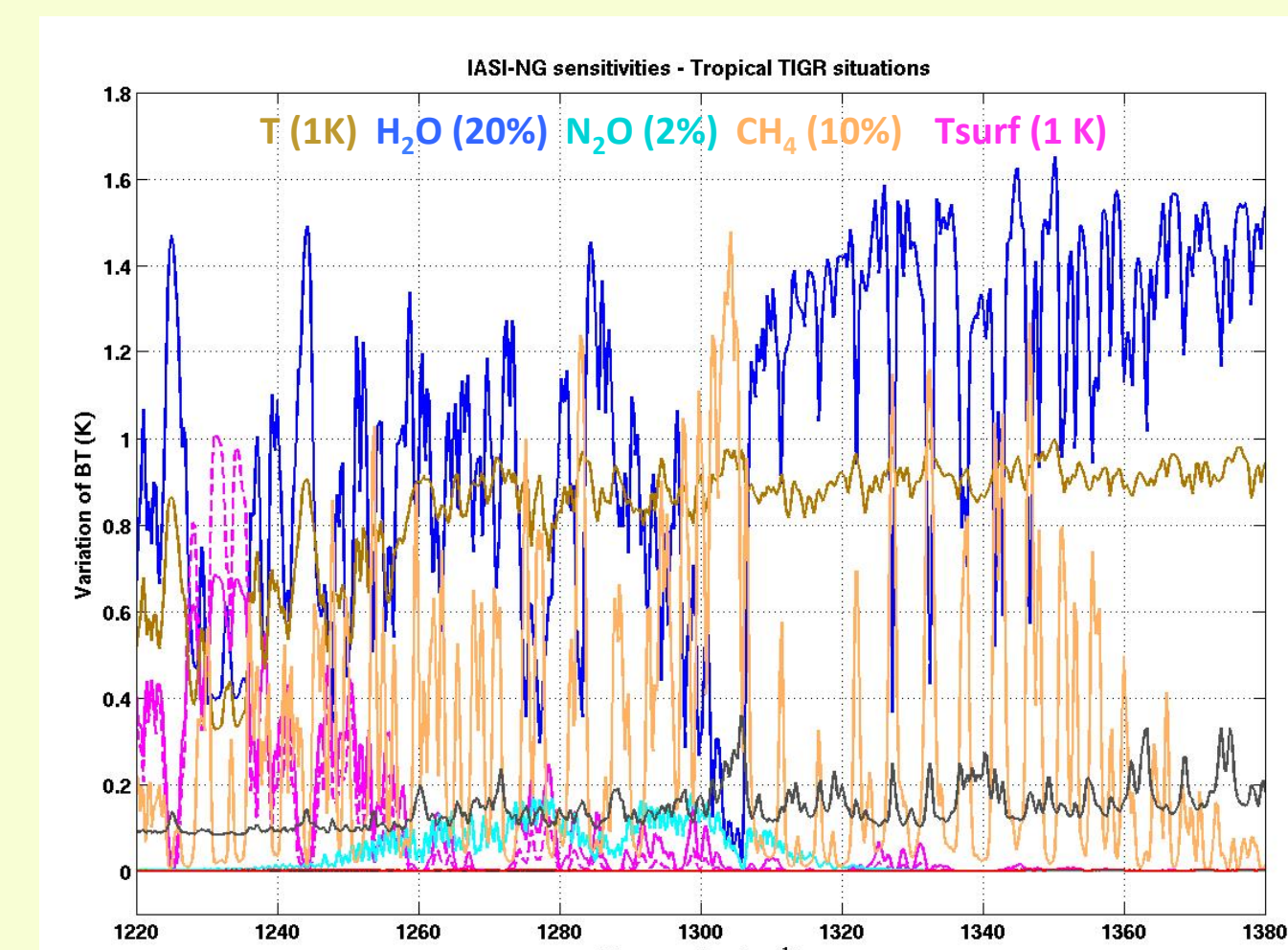
IASI, developed by CNES in collaboration with EUMETSAT, is a Fourier Transform Spectrometer based on a Michelson Interferometer coupled to an integrated imaging system that measures infrared radiation emitted from the Earth.

• Launched on 19th October 2006 onboard MetOp-A and declared operational in July 2007, IASI provides:

- 8461 spectral channels between 645 and 2760 cm⁻¹ (15.5 - 3.63 μm).
- with a spectral resolution of 0.5 cm⁻¹ after apodisation.
- the spectral sampling interval is 0.25 cm⁻¹.



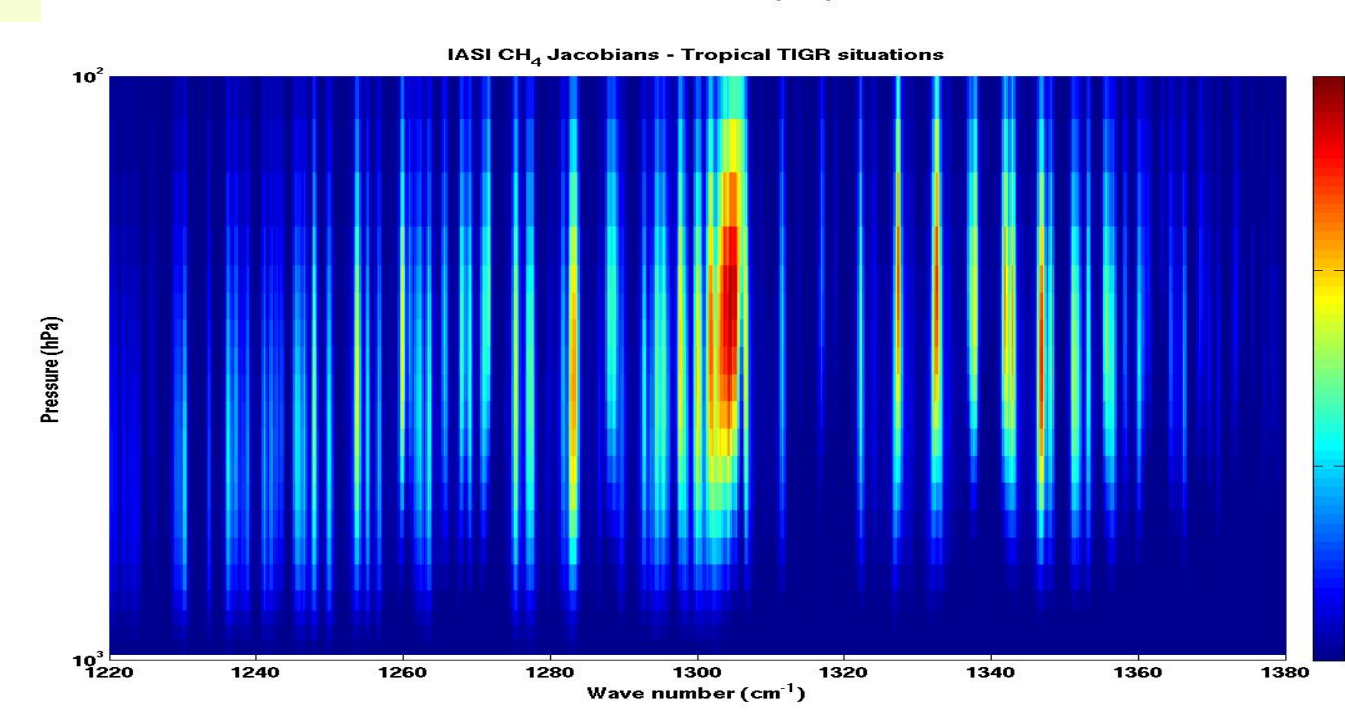
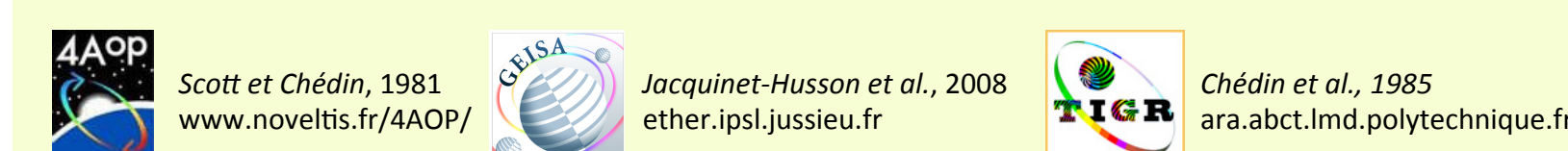
• IASI channels are sensitive to methane around 7.7 μm as can be seen in the figure below that shows the **variation of Brightness Temperature induced on each IASI channel by a typical variation of various atmospheric gas concentrations**.



For each channel and each TIGR situation, the variation of BT (in K) for a given variation of one atmospheric variable is computed using the 4AOP-2009 Jacobians:

$$\Delta T_B(T) = \sum_{n=1}^{n=42} \frac{\partial T_B}{\partial T}(nl) * \Delta T(nl) \quad \text{for temperature}$$

$$\Delta T_B(q_{gas}) = \sum_{n=1}^{n=42} \frac{\partial T_B}{\partial q_{gas}}(nl) * \Delta q_{gas}(nl) \quad \text{for a given gas}$$

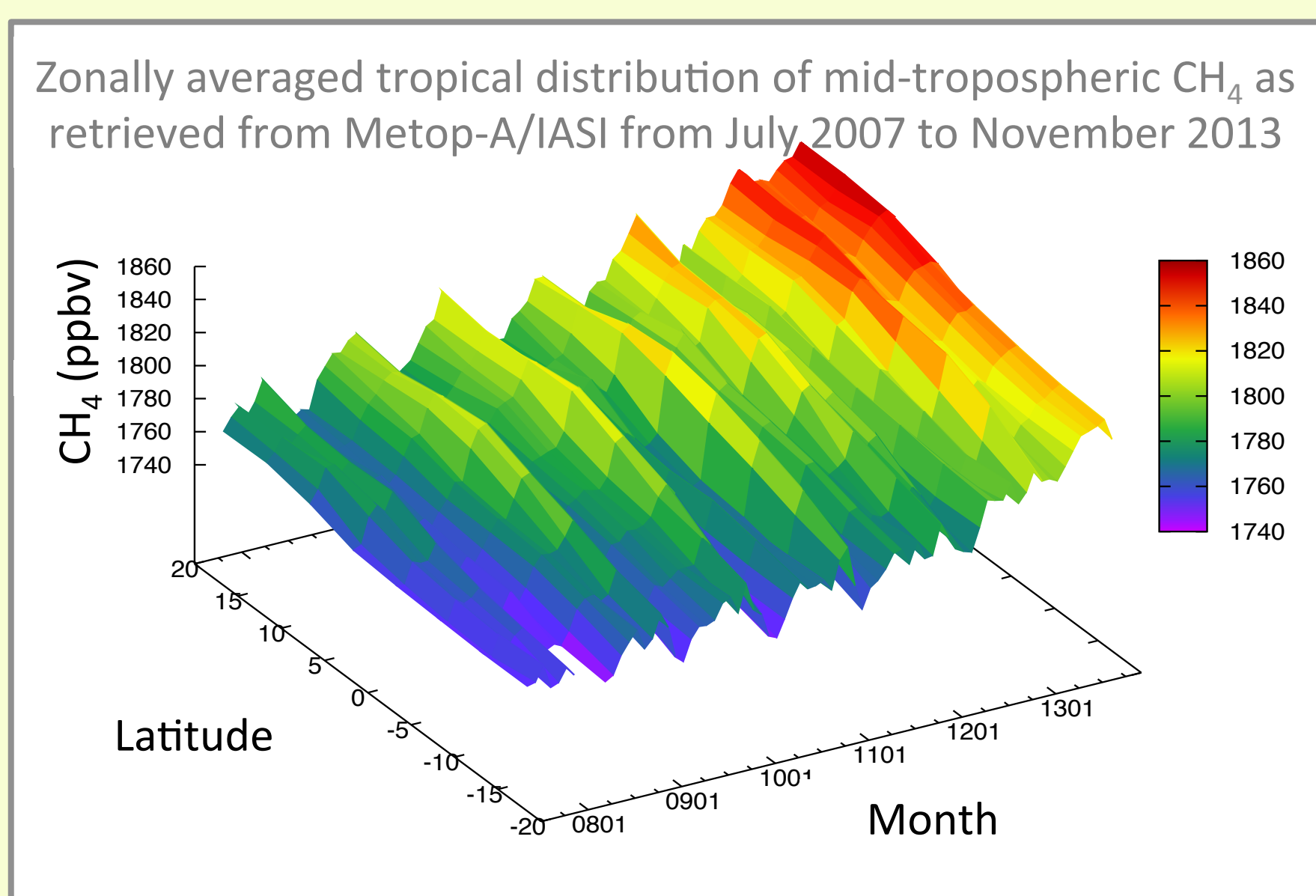


According to the CH₄ Jacobians, which are plotted on the left hand side, IASI channels are mostly sensitive to CH₄ in the mid-troposphere.

➔ Retrieval of a mid-tropospheric integrated content of CH₄.

• IASI data are routinely archived at LMD via the Ether Centre for Atmospheric Chemistry Products and Services (<http://ether.ipsl.jussieu.fr/>), through EUMETCast, the Broadcast System for Environmental Data of EUMETSAT.

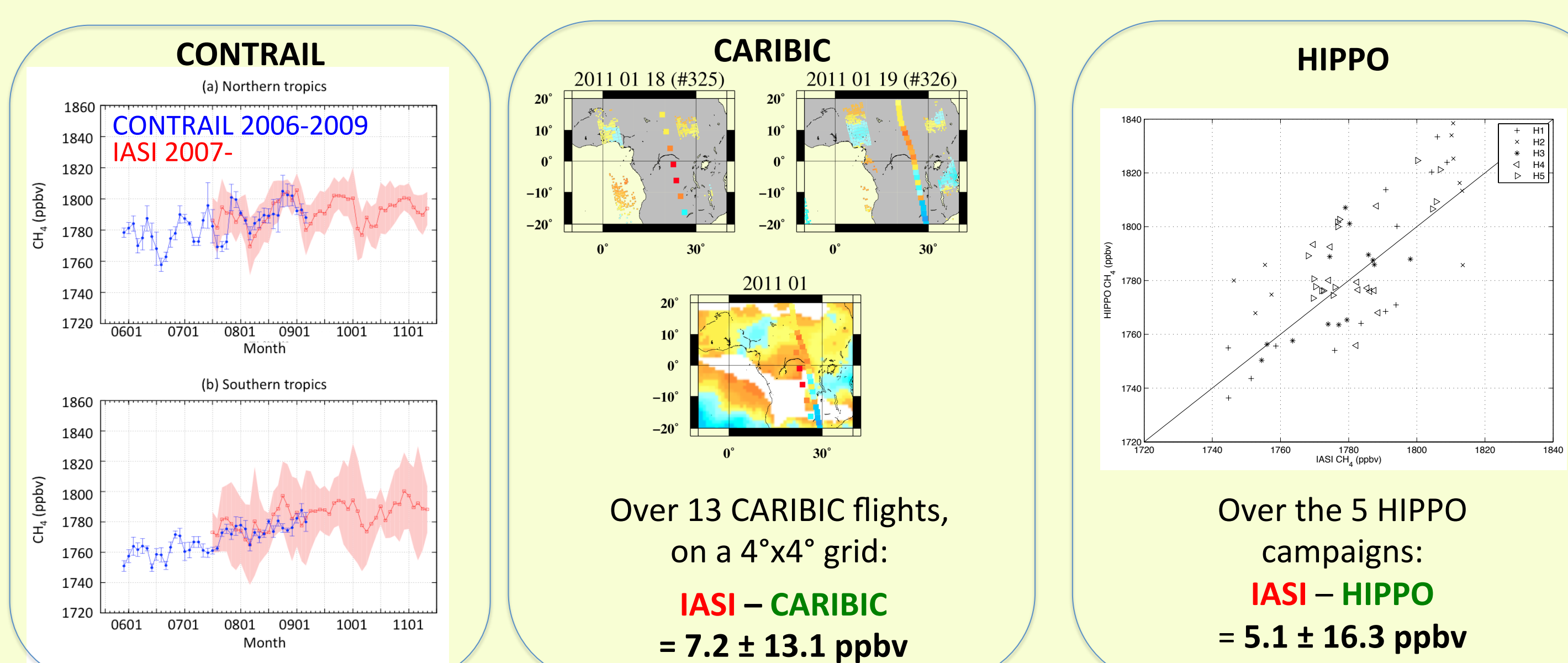
6.5 years of mid-tropospheric CH₄



• Seasonal cycle:

- more pronounced in the northern (~25 ppbv) than in the southern (~15 ppbv) tropics.
- In the northern tropics: maximum in November and minimum in March-April.
- In the southern tropics: more complex seasonal variation due to year-to-year fluctuations of UT wind distribution at ~200 hPa which modulates the inter-hemispheric transport during ENSO phases (Prinn et al., 1992), yielding enhanced exchanges in December-May during cold phases (as in 2007 and 2008), and a cancellation in the southern tropics of the summer minimum due to photochemical destruction of methane.

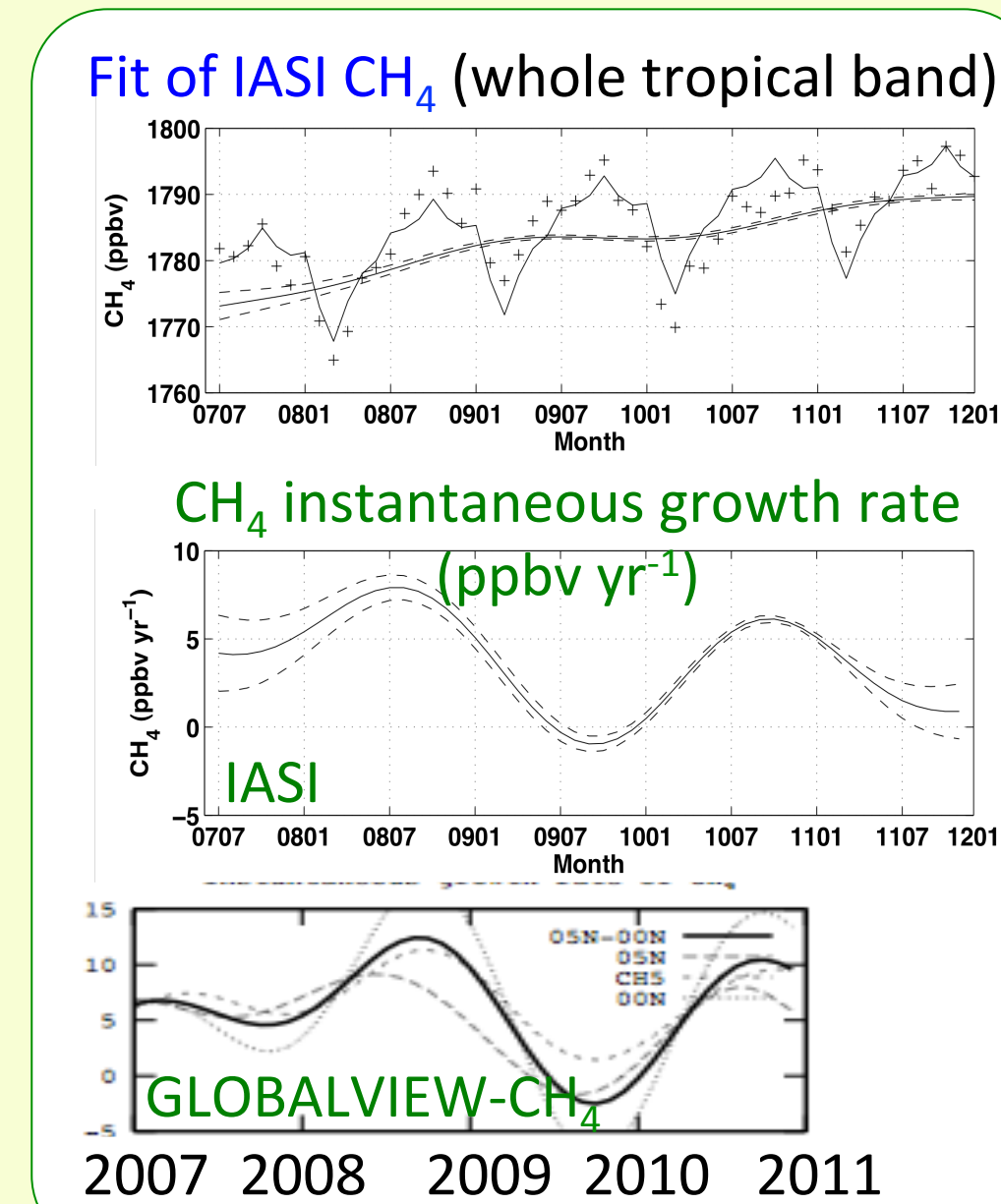
• Validation with aircraft measurements:



Year-to-year evolution

IASI shows an increase of mid-tropospheric CH₄ from 2007 to 2009, larger in the southern than in the northern tropics for 2007 and 2008, in agreement with the renewed growth of methane measured at the surface since the end of 2006 as shown by the GLOBALVIEW-CH₄ network.

This evolution is consistent with the increase of CH₄ emission from tropical wetlands due to enhanced La Niña precipitation in 2007 and 2008. IASI data suggests a slowing down of the increase in 2009, and a decrease in 2010. This evolution is in agreement with the evolution of precipitation in the tropics and the absence of significant change in fires, and thus in biomass burning CH₄ emission, in the tropical region over 2007-2009.

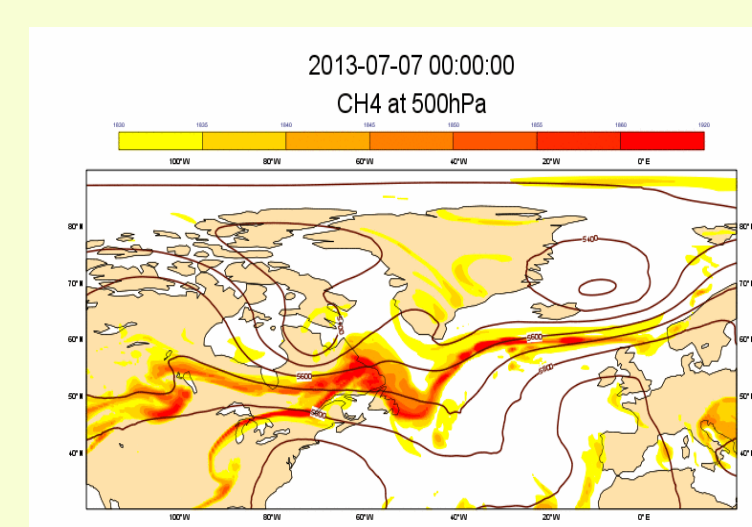


IASI has the potential to follow methane trend on the long-term.

Use of IASI CH₄

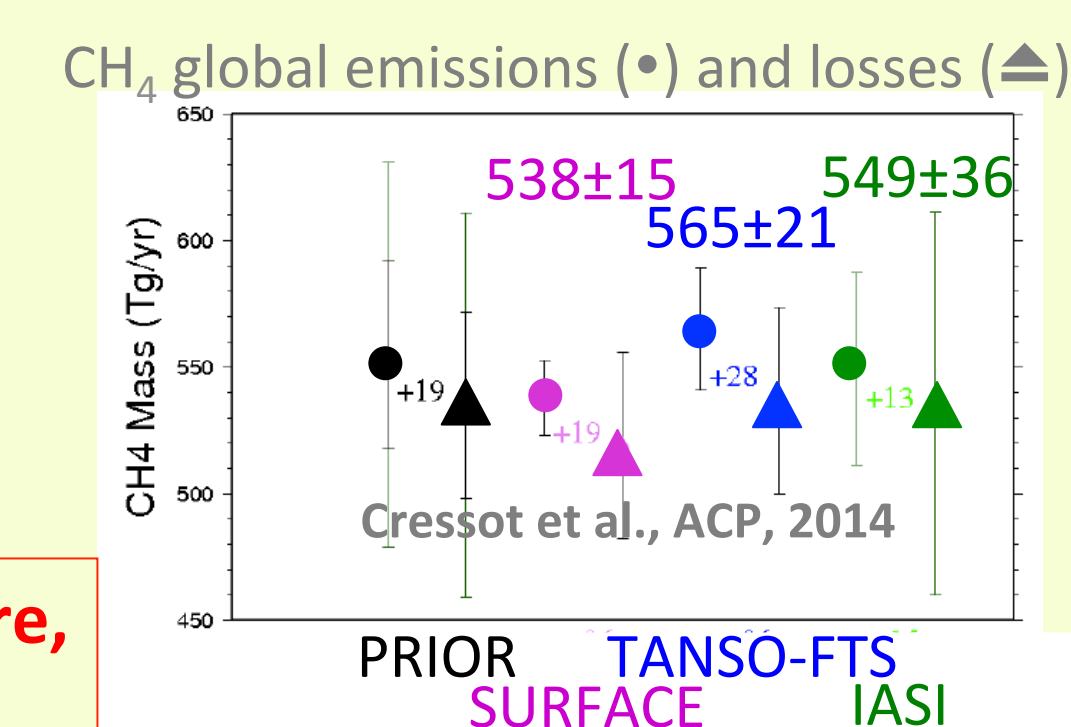
• MACC monitoring and assimilation:

- IASI CH₄ is assimilated within ECMWF/IFS since Dec. 2010 (Massart et al., 2014).
- In terms of column, the addition of the IASI data to TANSO data has a significant impact, mainly over extratropical regions, reducing the global bias.



• Surface fluxes estimation (August 2009-July 2010):

- Use of LSCE Bayesian inversion system.
- Use of **surface network** (NOAA), TANSO-FTS (UoL) and IASI (LMD) CH₄.
- Good statistical consistency between CH₄ flux estimates from each datasets.



Although IASI is mostly sensitive to the mid-troposphere, it does provide information on surface fluxes.

Conclusion

CH₄ fields retrieved from IASI seem to confirm that tropical wetland emissions driven by higher than average precipitation are one of the main drivers of the 2007-2008 increase. The 2010 decrease of methane suggested by IASI is also supported by the drop in precipitation over this year in wetland tropical region.

The results presented here show that IASI can provide a powerful constraint on the monitoring and understanding of atmospheric methane burden. With the launch of two other successive IASI-like instruments in 2012 and 2018, more than 20 years of observations of mid-tropospheric methane will be available for climate studies.